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Waste Management in Northfield
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Municipal waste is a nearly invisible problem with vast environmental consequences. It is well-established that waste generation is increasing: the U.S. produced 254 million tons in 2007, up from 88 million tons in 1960,[1] and, according to the U.S Environmental Protection Agency (EPA), the U.S. produces the most waste per person per day of any industrialized nation.[2] From the greenhouse gasses (GHG) and toxic leachate produced by landfills to the air pollution and hazardous ash produced by incineration to the recyclables sent to other countries that often end up in open dumps or uncontrolled burning,[3] throwing stuff away takes its toll. Although the 1976 Resource Conservation and Recovery Act (RCRA) successfully curtailed open dumping and uncontrolled dumping of hazardous waste,[4] landfills are likely to leak and continue to contaminate the environment well into the 21st century.[5]

The Northfield Context

Currently, Northfield contracts with Dick's Sanitation Inc. for trash and recycling collection from single-family residences, and residents pay a fixed fee for both services. Municipal waste is sent to the Rice County Solid Waste Facility, which includes a municipal solid waste (MSW) landfill, a construction and demolition dump, a hazardous waste dump and a yard waste dump.[6] According to a historical survey of waste management conducted by G. E. Louis, it is increasingly common for cities to contract with private companies for waste collection and disposal, in part due to the high level of technical expertise necessary to comply with complex regulations.[7] Dick's Sanitation provides single-stream recycling pickup to residents every other week and delivers the recycling to its Recycle Minnesota facility in Lakeville, MN, where it is processed and sold. Residents may also choose to subscribe to yard waste pickup by Dick's Sanitation for a fee. Although Dick's Sanitation is able to provide curbside pickup of food waste, that is not currently part of Northfield's contract due to the high cost and low public

[1] Shaufique F. Sidique, Satish V. Joshi, and Frank Lupi, "Factors influencing the rate of recycling: An analysis of Minnesota counties," *Resources, Conservation and Recycling* 54, no. 4 (February 2 2010).
[2] "Wastes," United States Environmental Protection Agency, accessed March 8, 2021, https://www.epa.gov/report-environment/wastes.
[3] *Where Will Your Plastic Trash Go Now That China Doesn't Want It?*, podcast audio, All Things Considered 2018, https://www.npr.org/sections/goatsandsoda/2019/03/13/702501726/where-will-your-plastic-trash-go-now-that-china-doesnt-want-it.
[4] Christina Chroni Katia Lasaridi, Antonis A. Zorpas, Konstantinos Abeliotis, "Waste Prevention," in *Sustainable Solid Waste Management*, ed. Jonathan W-C Wong et al. (Reston, Virginia: American Society of Civil Engineers, 2016), 64.
[5] The heavy plastic liners now used for landfill expected to last at least 30 years, but landfill decomposition will go on for hundreds. As a result, Lyle predicts a plague of leaking landfills. John Tillman Lyle, "Waste as a Resource," in *The Sustainable Development Reader*, ed. Stephen M. Wheeler and Timothy Beatley (New York: Routledge, 2004).
[6] Zero Waste Plan, (Northfield, MN: City of Northfield, MN, 2020).
[7] G. E. Louis, "A historical context of municipal solid waste management in the United States," *Waste Manag Res* 22, no. 4 (Aug 2004).

interest.[8] The City contract applies only to single-family residences; multi-family residences, commercial and industrial facilities, and institutions make their own contracts with a waste hauler of their choice. Northfield residents can dispose of larger items, such as furniture, by taking it to the Rice County Landfill for a fee or dropping it off during one of the City's Cleanup Days.[9] Finally, community members have the option to bring cardboard to dumpsters in Family Fare and Cub parking lots, and profits from these recycled materials benefit local schools.

Other organizations also play an important role in Northfield's waste management system, particularly in preventing and diverting waste. Although no city-wide composting program exists, residents may subscribe to food waste pickup by Northfield Curbside Composting. This worker cooperative began collecting compost in 2017 and received a Minnesota Pollution Control Agency Recycling Market Development grant in February 2021 to expand operations.[10] Residents may also take their food and yard waste to the Northfield Compost Site just south of town during the months of April to October and can pick up finished compost there as well. In addition, some organizations enable and promote the reuse of goods. Northfield Community Exchange is an organization created to facilitate the sharing of goods, skills, and services between community members in order to foster sustainability and social equity. The program has been in hibernation since 2016.[11] Northfield has second-hand clothing and furniture stores such as the Used-A-Bit Shoppe, the Thrifty Parrot, and the Clothes Closet. Carleton's Lighten Up Garage Sale also facilitates reuse by soliciting donations from college students and selling donated items to the Northfield community during a summer sale.

Waste collection in Northfield works well and may not appear to present a public crisis. Hotta & Suzuki analyzed two Japanese cities that dramatically reduced waste sent to final treatment sites; Yokohama by 42% between 2001 and 2010 and Kamakura by almost half.[12] These cities were highly motivated to address the waste problem because of the high cost and lack of capacity for incineration, which was the only final treatment strategy in these cities. In contrast, Northfield has not yet reached a crisis in landfill capacity, and as a result, the City might not view substantial investment in preventing waste as a priority. Nevertheless, it is essential to take action now to prevent a crisis in the future.

Waste in Northfield has become an increasingly urgent and environmentally costly problem largely hidden from public view. Landfills in this part of the state are filling up and waste diversion activities have failed to adequately reduce waste sent to landfill.[13] The Rice County Landfill has been in operation since 1976 and underwent an expansion in 2017 to extend the life of the landfill. There is no longer land available at the landfill site for further expansion. If the landfill reaches a point where it can no longer accept municipal waste, that waste will have

[8] Zero Waste Plan; Matthew Rohn, interview by Irene Stoutland and Riley Pohlman, 2021.
[9] Alexandra Miller, interview by Irene Stoutland, 2021.
[10] "About Us," Northfield Curbside Compost, accessed March 3, 2021, https://www.northfieldcompost.com/about-us; Dee DePass, "4 Minnesota recyclers receive grants totaling $400,000 from state program," *Star Tribune* (Minneapolis, MN), February 19 2021.
[11] "About," Transition Northfield, accessed March 3, 2021, http://transitionnorthfield.org/about-2/.
[12] Y. Hotta and C. Aoki-Suzuki, "Waste reduction and recycling initiatives in Japanese cities: lessons from Yokohama and Kamakura," *Waste Manag Res* 32, no. 9 (2014).
[13] Eric Roper, "Twin Cities faces 'pinch point' over landfilling," *Star Tribune* (Minneapolis, MN), January 25, 2021.

to be send elsewhere or a new site created to dump waste.[14] Waste prevention and improved waste management could extend the life of the landfill.

Northfield has been actively looking for ways to reduce and manage waste, and the City has ambitious waste management goals for the future. The City's Climate Action Plan (CAP) aims to implement a Zero Waste policy to be achieved by 2030 and eliminate organic material sent to landfill by 2025 by composting it.[15] To work towards these goals, the City has drafted a Zero Waste Plan (ZWP) that provides recommendations to help Northfield reduce waste sent to landfill by 90% from 2020 levels by 2030.[16]

As described in the ZWP, the Zero Waste approach focuses on "reducing consumption, conserving resources, and increasing reuse and recovery of materials in order to minimize or eradicate the amount of waste being sent to landfills and incinerators."[17] This approach works in tandem with the waste management hierarchy, which prioritizes waste reduction, followed by reuse, recycling, composting, waste-to-energy, and landfill.[18] The Zero Waste concept is relatively new and not well codified in the literature: in a 2017 literature review, Pietzsch et al. determine that scholars have not yet reached a consensus regarding the social, political, economic, and environmental characteristics of Zero Waste.[19] The term lacks a clear definition in the literature; some authors use it to mean strictly eliminating waste sent to landfills, others to describe preventing waste or creating a more circular economy in general. In fact, in a review focused on recycling and waste prevention in the E.U., Bartl asserts that "'Zero waste' is a term which is inflated and abused almost constantly in waste management today."[20] Scholars are also inconsistent in their capitalization of the term. For the purposes of this project, I will rely on the definition of Zero Waste provided by the ZWP in order to be consistent with Northfield's goals and ideas about Zero Waste.

Northfield's ZWP recommends strategies to raise awareness about Zero Waste; to prevent and manage construction and demolition waste; to recover materials from waste through recycling and composting; and to reduce waste produced by city buildings and operations, as well as residential, industrial, and commercial entities. More specifically, the ZWP focuses on

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[14] *In The Matter of the Decision on the Need for an Environmental Impact Statement for the Proposed Rice county Landfill Expansion, SW-123* Minnesota Pollution Control Agency (Bridgewater Township, Rice County, MN, 2017), https://www.pca.state.mn.us/sites/default/files/p-ear2-126b.pdf; Miller, interview.

[15] Northfield Climate Action Plan, (Northfield, MN: City of Northfield, MN, 2019), 38.

[16] Zero Waste Plan, 2.

[17] Zero Waste Plan.

[18] Terms such as reduction, prevention, and minimization are often used interchangeably and inconsistently. In this paper, reduction will refer to a decrease in materials that need to be disposed of, which is closely tied to consumption of goods. Prevention will refer to preventing materials from entering the waste stream, including through reduction and reuse. Reuse refers to continued use of products in their current form, for example, repurposing old items or purchasing second-hand goods. Waste diversion indicates waste not sent to the landfill but instead diverted for recycling or composting, both of which involve transforming materials through mechanical or biological processes. Waste-to-energy and landfill are both end-of-life management strategies that remove materials from the realm of human use.

[19] Natália Pietzsch, José Luis Duarte Ribeiro, and Janine Fleith de Medeiros, "Benefits, challenges and critical factors of success for Zero Waste: A systematic literature review," *Waste Management* 67 (2017).

[20] A. Bartl, "Moving from recycling to waste prevention: A review of barriers and enables," *Waste Manag Res* 32, no. 9 Suppl (2014).

community-based social marketing to address attitudes towards waste at the individual level by "changing social norms, providing incentives, and making sustainable behaviors convenient."[21] This plan promotes education through the City website and events such as the Defeat of Jesse James Days, recycling training programs, consistent signage, educating children in the public schools about waste, promoting product reuse and reusable products, reaching out to the public through various media, and creating a rewards program to recognize businesses and individuals who take actions toward Zero Waste. It is unclear whether these recommendations will be sufficient to fully eliminate waste sent to landfill, but they will go a long way towards preventing and diverting waste from the landfill. I fully endorse the thorough list of recommendations outlined in the ZWP. My proposals build on the ZWP by outlining waste prevention actions beyond those mentioned in the ZWP and addressing topics not covered in the ZWP, such as measurement of waste prevention, community-based recycling, and the need for state and national legislation.

Goals: Going Beyond Diversion

It is important to address the waste problem at multiple levels on the waste management hierarchy: prevention is preferred, but diversion through recycling and composting is also important. As a result, waste prevention is the primary goal of my plan for Northfield, but I also include suggestions to improve waste diversion. These goals are in line with City intentions, as described in the CAP and ZWP.

Waste prevention is the most environmentally sound solution to the waste problem: Esmaeilian et al. found that it conferred the greatest effectiveness at lowest cost compared to diversion and disposal strategies or environmental cleanup of waste.[22] But total elimination of waste is not a reasonable short-term goal; Lasaridi et al. conclude that waste prevention could not be expected to exceed 10-15% in the foreseeable future.[23] The bulk of the remaining waste must be diverted from the landfill through recycling and composting. Recovering materials from waste can be profitable in Minnesota. [24] In addition, the consensus in the field of urban metabolism is that recovering the outputs of the urban system (waste) through recycling and composting and using these materials to replace new inputs (raw materials) creates a circular economy and

[21] Zero Waste Plan, 8.
[22] Behzad Esmaeilian et al., "The future of waste management in smart and sustainable cities: A review and concept paper," *Waste management (Elmsford)* 81 (2018).
[23] Katia Lasaridi, "Waste Prevention," 85.
[24] In 2010, 2.5 million tons of recycling worth $690 million was collected in Minnesota. An additional 1.2 million tons of recyclable material worth $285 million was landfilled at a cost of $200 million. "Demographics of garbage," Minnesota Pollution Control Agency, updated October 31, 2013, accessed February 17, 2021, https://www.pca.state.mn.us/featured/demographics-garbage.

reduces our environmental impact.[25] Zaman & Lehmann have found a way to quantify this benefit, as explained further under 'Achieve Reliable Measurement of Waste Prevention.'[26]

But waste diversion alone cannot solve the waste problem. Recycling programs may require financial support and mishandling can lead to enormous social and environmental costs. For example, in 1987, New Jersey became the first state to make recycling mandatory and for years remained a national leader in recycling rate. But more recently, the recycling program has declined substantially because of a lack of state and local aid to finance recycling programs.[27] Even when recycling is successfully collected, it may be sent to developing countries, landfilled or burned, or stockpiled, rather than transformed into new materials.[28]

In addition, an overemphasis on the merits of waste diversion can actually increase waste production. In her book *Circular Approach in Green Planning Towards Sustainable Cities*, Monica Lavagna writes that putting too much faith in recycling and composting can lead to the rebound effect, whereby people increase consumption because they trust that recycling will take care of the waste problem.[29] According to Messner et al., this "contributes to a normalization of unsustainable production and consumption while preempting questions of responsibility and social license to create waste."[30] Waste diversion, in other words, is not a substitute for waste prevention, but a complementary strategy.

Unfortunately, waste prevention is often conflated with diversion, and this confusion presents a barrier to effective waste prevention policy. Preventing waste requires us to examine production and consumption trends, attitudes and perceptions about waste, and barriers to changing the social, economic, and political norms that encourage the production of vast amounts of waste. Diversion in comparatively simple: add another bin and divert collected materials to recycling or composting facilities. Many attempts to fix the waste problem, including the Resource Conservation and Recovery Act (RCRA), have focused on diverting waste to recycling and other end-of-pipe strategies, rather than promoting waste prevention measures.[31] Although the circular economy approach is widely acknowledged and supported in

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[25] Yan Zhang, "Urban metabolism: A review of research methodologies," *Environmental Pollution* 178 (2013); Monica Lavagna, "Circular Approach in Green Planning Towards Sustainable Cities," in *Green Planning for Cities and Communities: Novel Incisive Approaches to Sustainability,* ed. Giuliano Dall'O (Cham, Switzerland: Springer International Publishing, 2020); Herbert Girardet, "The Metabolism of Cities," in *The Sustainable Development Reader*, ed. Stephen M. Wheeler and Timothy Beatley (New York: Routledge, 1999).

[26] Atiq Uz Zaman and Steffen Lehmann, "The zero waste index: a performance measurement tool for waste management systems in a 'zero waste city'," *Journal of Cleaner Production* 50 (2013).

[27] S. A. Abbasi, "The myth and the reality of energy recovery from municipal solid waste," *Energy, Sustainability and Society* 8, no. 1 (2018), 4.

[28] Most of our plastic - 700,000 tons/year from the U.S.by 2016 - used to go to China, where it would be recycled using cheap labor. The portion that wasn't recyclable was dumped or burned, producing air pollution and contaminating farmland, and in January 2018, China banned almost all imports of plastic trash. US recyclers are trying to pick up the slack, but much of the material "recycled" in the U.S. is either landfilled or stockpiled. "Where Will Your Plastic Trash Go Now That China Doesn't Want It?"

[29] Lavagna, "Circular Approach in Green Planning Towards Sustainable Cities," 1.

[30] Rudolf Messner, Carol Richards, and Hope Johnson, "The 'Prevention Paradox:' food waste prevention and the quandary of systemic surplus production," *Agriculture and Human Values* 37, no. 3 (2020).

[31] Katia Lasaridi, "Waste Prevention," 64.

the literature,[32] Messner et al. conclude that it is often "narrowly interpreted in practice as largely aimed at reducing landfill while systems-change is often not emphasized."[33] This is complicated by the fact that consumption and waste production are closely tied to economic growth. According to Bartl, recycling is prevalent because it can create profit and does not interfere with consumption, whereas prevention efforts can create conflicts of interest for those who profit from high levels of consumption and waste: manufacturers and distributers, as well as the waste management and recycling sectors.[34] Although preventing waste is more difficult than diverting it, focusing City policy only on recycling and composting is insufficient – a long term plan to achieve Zero Waste must work to change production, consumption, product use and reuse, and public attitudes towards waste. Preventing waste may be difficult, but it is a reasonable long-term goal and there are specific steps that Northfield can take to achieve it.

In addition to waste prevention and diversion – the goals of my proposal – smart landfill management is also important to mitigate the negative environmental effects of waste. But because Northfield does not own a landfill, changes in this area would require actions by the Rice County Solid Waste Facility or significant infrastructure investment. My plan does not focus on landfill management, but strategies for converting waste to energy and reducing greenhouse gas (GHG) emissions from waste through landfill gas capture are discussed in Appendix 1.

There is no quick and easy way to fix the waste problem; the recommendations I present here are ambitious and intended to be part of a broad, 20-year vision for managing waste. The following sections focus on the current scholarship in the field of waste prevention and management, including specific applications to the Northfield context of strategies supported by the literature.

The focus areas of my plan are the following:

1. Achieve reliable measurement of waste prevention and diversion (<5 years)
2. Prioritize waste prevention through initiatives to influence consumer behavior and attitudes about waste (<10 years)
3. Encourage local participation in waste prevention and recycling of certain items (10-15 years)
4. Encourage broader social, economic, and political change in the waste management arena by supporting state and national legislation (10-20 years)

The timeline provided is meant to be a general guide that reflects the priorities of my proposed plan. Measurement is highlighted first because it is essential to begin measurement before waste prevention and diversion initiatives are implemented. This establishes a baseline

[32] Anne P. M. Velenturf and Phil Purnell, "Resource Recovery from Waste: Restoring the Balance between Resource Scarcity and Waste Overload," *Sustainability*, no. 9 (2017); Atiq Uz Zaman and Steffen Lehmann, "Urban growth and waste management optimization towards 'zero waste city'," *City, Culture and Society* 2, no. 4 (2011); Lavagna, "Circular Approach in Green Planning Towards Sustainable Cities."

[33] Messner, Richards, and Johnson, "The 'Prevention Paradox': food waste prevention and the quandary of systemic surplus production."

[34] Bartl, "Moving from recycling to waste prevention: A review of barriers and enables."

and allows future measurement to show improvements and reflect the success of policies and projects. The next section focuses on recommendations for waste prevention, including strategies to educate the community and incentivize waste prevention. It is important to prioritize waste prevention because it is the ideal strategy to address the waste problem, and from a practical standpoint, my recommended waste prevention strategies are relatively simple and low-cost. In addition, fostering community awareness of waste prevention will encourage support for more ambitious elements later in the proposal. The third section explains the social and environmental benefits of community-based recycling efforts and outlines ways that Northfield can encourage these initiatives. This stage is more complex than the waste prevention section because it requires increased community participation and establishment of sustained programs. As a result, this stage comes after waste prevention and will be supported by earlier measures to build public enthusiasm for waste prevention and improved management. The final section recommends that Northfield support state and national policy goals that will help the City achieve Zero Waste. These broader changes will likely take longer to be implemented than the previous stages and go beyond what Northfield can do as an individual city to address the waste problem. As a result, these broader changes are a lower priority for Northfield and represent a longer-term investment in waste management.

1. Achieve Reliable Measurement of Waste Prevention

Effectively measuring waste prevention and diversion is a crucial element of waste management that lets policy makers, local authorities, and community actors know whether waste management efforts are working.[35] Hard evidence demonstrating the effectiveness of Zero Waste ordinances, incentives, and outreach efforts is essential to garner support for future policies. Funding and strategies for measurement must be incorporated into any waste prevention or management initiative, including the waste prevention actions recommended below. Measurement must begin before implementation of a given policy in order for the data to reflect improvements correlated with that policy. As a result, Northfield should prioritize establishing methods to reliably measure waste production within the next 5 years in order to provide a baseline against which to measure future improvements.

Northfield already has plans to measure waste diversion and evaluate the effectiveness of recycling and composting programs. Diversion rate - the amount of waste collected that is not sent to the landfill - indicates the use of recycling and composting programs. Rice and Dakota Counties collect data that can be used to estimate the portion of Northfield's waste that is landfilled, recycled, composted, and sent to waste-to-energy facilities.[36] For example, in 2019, an estimated 46% of Northfield's waste was sent to landfills, 52% to recycling centers, 2% to waste to energy facilities, and <1% was composted.[37] Although this data appears to indicate the success of city-wide recycling, it does not reveal how much of the landfilled waste could have been recycled or whether materials sent to the recycling facility were successfully recycled.

[35] V. Sharp, S. Giorgi, and D. C. Wilson, "Methods to monitor and evaluate household waste prevention," *Waste Manag Res* 28, no. 3 (Mar 2010).
[36] Northfield Climate Action Plan.
[37] Northfield Climate Action Plan.

Fortunately, the City's 2019 contract with DSI includes a plan for annual waste sorts that will provide information about the composition of waste, including how much organic and recyclable waste is being landfilled,[38] which over time could illustrate the impact of initiatives to encourage people to recycle, compost, and sort waste correctly.

Waste diversion data is an important indicator of how well the City is recycling and composting. By using waste diversion data to estimate the potential amount of virgin material avoided through material recovery, the energy and water saved, and the reduction in GHG emissions due to waste management efforts, Zaman & Lehmann developed a Zero Waste Index that evaluates the broader environmental impacts of a city's waste diversion efforts.[39] Northfield might consider using existing waste diversion data to calculate a Zero Waste Index and better assess the City's efforts to reduce the environmental harm of its waste. It is important to note here that the Zero Waste Index does not take into account waste prevention, only diversion. Because robust strategies for measuring waste diversion in Northfield already exist, my recommendations focus on a more difficult task: measuring waste prevention.

As Zorpas & Lasaridi demonstrate in their 2013 analysis of various measurement strategies, waste prevention is inherently difficult to measure because participation is not visible. While we can directly measure how much waste is recycled vs landfilled, it is difficult to measure how much waste people avoid producing.[40] Sharpe et al. and Lasaridi et al. both point out that even if a reduction in overall waste is observed, it is difficult to link the reduction to specific policies or measures; a decrease may be the result of economic recession or some other unknown cause. Finally, it is difficult to determine whether an observed decrease in waste is maintainable or simply accidental; an individual might produce less waste unintentionally, perhaps by buying a product with less packaging because a preferred product was not available, rather than in an attempt to reduce waste or as a response to a particular waste reduction initiative.[41]

Recommendations for Measurement of Waste Prevention

a. Establish a baseline before any intervention to allow for later comparison
b. Combine attitude and behavior surveys, participant monitoring, and collection data
c. Use pilot and control groups to link specific programs to observed trends
d. Consider hiring a City Volunteer Coordinator to organize data collection by residents

The literature concerning measurement of waste prevention agrees that measurement is crucial to inform policy makers but does not reach a consensus about the best way to do so. Zorpas & Lasaridi analyze myriad strategies for measuring waste prevention and conclude that

[38] Zero Waste Plan.
[39] Zaman and Lehmann, "The zero waste index: a performance measurement tool for waste management systems in a 'zero waste city.'"
[40] Antonis A. Zorpas and Katia Lasaridi, "Measuring waste prevention," *Waste Management* 33, no. 5 (2013).
[41] Katia Lasaridi, "Waste Prevention," 84; Sharp, Giorgi, and Wilson, "Methods to monitor and evaluate household waste prevention."

each strategy presents unique challenges.[42] According to these authors, no one strategy for measuring waste prevention is sufficient. Sharp et al. analyze several studies between 2005 and 2010 that attempted to measure waste prevention by asking households to weigh the waste they produce; although this strategy measures waste directly and provides motivational feedback for participants, samples are usually small due to the need for direct contact with participants, and data quality is undermined by high drop-out rates and the fact that the sample is biased by self-selection. Monitoring the number of participants signed up for services such as curbside composting makes data collection easier and can provide feedback on specific initiatives but provides only indirect data on waste prevention and is only applicable to certain types of waste. Attitude and behavior surveys are easier to implement than participant monitoring, but samples are often biased, and respondents tend to overestimate their own waste prevention contribution. Modeling can prove useful but depends on high-quality data and reliable estimation tools. Finally, waste collection data, such as weighing garbage trucks to determine how much waste they collected, can provide reliable and consistent information on general waste production but cannot identify the cause of any observed trends.[43]

A combination of measurement strategies is the most reliable way to evaluate waste prevention. Both Zorpas & Lasaridi and Sharpe et al. conclude that combining baseline and follow-up surveys before and after a waste prevention program with participant monitoring and waste collection data during the effort can indicate whether the total volume of waste is decreased, how that is happening (such as an increase in recycling or composting), and why participants are choosing to manage their consumption and waste differently.[44] Participant monitoring and surveys provide context for collection and composition data and help identify whether specific initiatives are the cause of changes in waste production. Pilot and control groups are a particularly effective way to evaluate a specific waste prevention effort, but this strategy requires long-term planning to ensure no change in service for the control group, well-matched participant groups, an understanding of external influencing factors, and detailed collection data.[45] One reason it is particularly difficult to evaluate community-wide programs is because of the lack of a control group. In addition, collecting data that reflects change over time can be challenging. Zorpas & Lasaridi suggest that a year of monitoring before implementation of waste prevention measures can provide more useful longitudinal data than shorter baseline measurement periods. Ultimately, effective measurement depends on good planning; this includes establishing a baseline before an intervention effort and allocating funding in the project budget for data collection and analysis after the intervention.

Some of the preparation and data collection necessary to quantify waste production and prevention, such as surveys and participant recruiting for more in-depth studies, could be completed by volunteers. A partnership with the colleges could allow students to help process and analyze data trends. In order to facilitate these collaborations, the City might consider hiring

[42] Zorpas and Lasaridi, "Measuring waste prevention."
[43] Sharp, Giorgi, and Wilson, "Methods to monitor and evaluate household waste prevention."
[44] Zorpas and Lasaridi, "Measuring waste prevention."; Sharp, Giorgi, and Wilson, "Methods to monitor and evaluate household waste prevention."
[45] Sharp, Giorgi, and Wilson, "Methods to monitor and evaluate household waste prevention."

a Volunteer Coordinator. This new staff person could help implement reliable measurement of waste prevention, as well as supporting the later sections of this plan and connecting community members with other projects and initiatives in Northfield.

2. Prioritize Waste Prevention

Waste prevention is the preferred solution to the waste problem and should be prioritized in Northfield's efforts to achieve Zero Waste. Preventing waste decreases the burden on the waste management system, lessens the environmental impact of waste, and decreases costs of collection and disposal. In fact, Olofsson investigated the national Swedish waste management system and estimated that 4% waste prevention could lead to a 5-9% reduction in landfill greenhouse gas emissions. It is reasonable to infer that a similar reduction in emissions could be achieved through waste prevention in the U.S.[46]

Many of my recommendations involve holistic educational and social marketing-based approaches that require minimal infrastructure investment. As a result, this stage of the plan can easily begin within 10 years. The strategies I recommend aim to directly reduce waste production and build support for later stages of the plan. Education, awareness campaigns, and incentives will encourage community support for local recycling and composting programs and for City ordinances, as well as state and national policies, that make it easier for consumers to avoid producing waste.

Waste Prevention Recommendations

a. Showcase community support for waste prevention and diversion
b. Teach kids about waste prevention, recycling, and composting through programs in schools
c. Encourage recycling and composting as complementary strategies to waste prevention, not an excuse to produce more waste, and make waste sorting information widely available
d. Emphasize the individual financial benefits of waste prevention through education efforts
e. Take advantage of strategies that make waste prevention convenient for residents
f. Create financial incentives for individuals and businesses to prevent waste
g. Complement top-down policies with education efforts, opportunities for community engagement, and positive reinforcement

Showcasing community support for waste prevention is a powerful tool to encourage waste prevention behavior. Lasaridi et al. argue that if community members assume that retailers and corporations are responsible for the waste problem and that their individual contribution is too small to matter, they are unlikely to change their behavior.[47] In contrast, people are more likely to make an effort to prevent waste if they see those around them are doing so. When

[46] Emmanuel C. Gentil, Daniele Gallo, and Thomas H. Christensen, "Environmental evaluation of municipal waste prevention," *Waste Management* 31, no. 12 (December 1, 2011).
[47] Katia Lasaridi, "Waste Prevention," 81.

Northfield Curbside Composting started providing yard signs to subscribers so that their neighbors could learn about the program and how to sign up, the organization saw an uptick in subscriptions.[48] Providing other easy ways for community members to showcase their waste prevention efforts may serve as a motivating factor for other members of their neighborhood. This strategy is supported by a study by Ferraro and Price which found that social comparison messaging was more effective than information dissemination in reducing water consumption.[49] This study also found that the impact of promotional messages decreased over time, so messaging must be periodically updated to avoid complacency among the target audience. Additional ways that the city could showcase support for waste prevention include providing yard signs to households that participate in waste reduction training or opt for a smaller trash bin or initiating a certification program that recognizes residents who volunteer their time to promote waste prevention and diversion in their neighborhoods and throughout the city. For example, individuals could become "Waste Warriors" after volunteering for a certain number of hours at repair fairs, or by going door-to-door to educate their neighbors about waste prevention, collecting items for donation or recycling, etc. If residents perceive that their community is working to reduce waste sent to landfill, they will be less likely to feel that their individual efforts are insignificant and more likely to engage in waste prevention behavior. People are also influenced by contact with city government; Hotta & Suzuki's analysis of waste reduction in Yokohama and Kamakura found that direct, personal contact by local government was one of the major factors influencing public participation in recycling programs.[50]

Education is another important element in improving waste prevention and diversion. Pietzsch et al. conducted a systematic literature review of the Zero Waste field and concluded that education initiatives are a critical factor for the success of Zero Waste.[51] Education at a formative age through clubs and programs that teach waste separation, encourage kids to collect profitable recyclables to raise money, and practice school level composting can help teach younger generations how to easily incorporate waste diversion into daily life. These lessons can also introduce easy ways to prevent waste, such as using reusable water bottles, reusing glass jars for food storage, and much more. Kids can bring ideas about waste prevention and diversion home to their families and communities, thereby amplifying the effect of education initiatives. Education for adults is important, too. Sidique et al. conducted a rigorous study of Minnesota counties and found that education expenditures for all residents were a predictor of recycling rates.[52] Including informative signage on trash and recycling containers can also make it easier for residents to sort waste correctly; however, confusion about what can be recycled and how to do so often relates to specific products – for example, should bottles be recycled with or without the caps? Can books be recycled? I recommend publishing a booklet with detailed

[48] Helen Forsythe, interview by Irene Stoutland and Riley Pohlman, 2021.
[49] Paul J. Ferraro and Michael K. Price, "Using Nonpecuniary Strategies to Influence Behavior: Evidence from a Large-Scale Field Experiment," *The Review of Economics and Statistics* 95, no. 1 (2013).
[50] Hotta and Aoki-Suzuki, "Waste reduction and recycling initiatives in Japanese cities: lessons from Yokohama and Kamakura."
[51] Pietzsch, Ribeiro, and de Medeiros, "Benefits, challenges and critical factors of success for Zero Waste: A systematic literature review."
[52] Sidique, Joshi, and Lupi, "Factors influencing the rate of recycling: An analysis of Minnesota counties."

product-by-product recycling instructions for Northfield's recycling system and making this information easily available on the City website. These efforts may increase the amount of waste diverted from the landfill and decrease contamination of recycling. It is important to note that education initiatives focused on recycling and composting must emphasize that diversion is not a substitute for waste prevention.

Education efforts that emphasize the economic benefits to individuals and households could also help motivate direct actions that would prevent waste. This approach encourages people to adopt waste prevention behaviors not purely out of concern for the environment, but also out of self-interest. Although many people care about the environment and support sustainability efforts, translating this general concern into specific action can be difficult. People may assume that an action will be inconvenient without even trying it and may not realize that it confers individual benefits. For example, repurposing objects and buying items second-hand can both save people money and prevent waste. Education initiatives could focus on the cost-saving elements of waste prevention, such as buying refillable and reusable products, paying less for a smaller trash bin, and spending less on groceries by reducing food waste at home. The City can publicize these individual financial benefits as a way to encourage waste prevention. For example, social media campaigns and signs in the grocery store that show people how to cook root-to-stem - a technique that reduces food waste by using every part of a fruit or vegetable - could help shoppers use their produce more efficiently, both saving them money and reducing food waste.

Waste prevention and diversion measures that require little effort on the part of residents represent low hanging fruit for decreasing waste in Northfield. Visvanathan & Kashyap argue that convenience is one of the key factors determining whether individuals participate in waste prevention. In addition, a study by Gregson et al. concluded that making waste prevention easier for residents was an important strategy for encouraging behavior change.[53] Actions as simple as providing residents with "no junk mail" stickers have been shown to be effective in reducing unwanted advertising that contributes to paper waste.[54] Allowing residents to opt in to receiving the weekly free copy of the *Northfield News Supplement,* rather than automatically sending it to all households, would also reduce waste. Policies such as these do not ask residents to go out of their way to prevent and divert waste and, as a result, have the potential for quick and widespread impact.

Implementing financial incentives for waste prevention can also encourage individuals and businesses to produce less waste. In his analysis of factors enabling and limiting waste prevention and recycling, Bartl concludes that realigning financial incentives to promote waste prevention is a crucial step in combating the waste problem.[55] The Comprehensive Plan for Northfield recommends volume-based pricing for waste,[56] and the city could move in this

[53] Nicky Gregson et al., "Moving up the waste hierarchy: Car boot sales, reuse exchange and the challenges of consumer culture to waste prevention," *Resources, Conservation and Recycling* 77 (August 1, 2013).
[54] Katia Lasaridi, "Waste Prevention," 79.
[55] Bartl, "Moving from recycling to waste prevention: A review of barriers and enables."
[56] Comprehensive Plan for Northfield, (Northfield, MN: City of Northfield, MN, 2008), page 12.11.

direction by increasing the price difference between large and small garbage containers.[57] Currently, Northfield charges $11.10 for a 20 gallon trash bin and $12.30 for a 35 gallon bin[58], which represents an 11% increase in price. In contrast, San Francisco, a leading city in the march towards Zero Waste, charges 16% more for a 32 gallon landfill bin ($52.59) compared to a 16 gallon bin ($45.48).[59] The ZWP recommends establishing waste prevention incentives through a rewards program for businesses.[60] More specifically, I recommend providing a certification to businesses that participate in the Minnesota Chamber of Commerce Waste Wise program, which works with companies to prevent waste, save money on waste collection service, train employees in waste diversion, and connect businesses with grants to fund recycling improvements.[61] Recognizing businesses that reduce plastic bag usage would also be worthwhile. This may encourage the sale and use of reusable bags and serve as a stepping stone towards an ordinance requiring stores to charge for plastic bags. This type of reinforcement would be good for business by providing publicity for stores that support environmental initiatives, and it would help the city garner support for restrictions on single-use plastics.

Both the ZWP and CAP also recommend zero-waste packaging ordinances.[62] This is a valid goal, but such an effort must be preceded and supported by education efforts that highlight the personal and environmental benefits of waste prevention, opportunities for the community to provide input and feel ownership of the measure, and programs that provide positive reinforcement for waste prevention, rather than penalties for waste production. Top-down policies and penalties for waste production that lack public support can anger and alienate residents and businesses and encourage non-compliance. In fact, based on theoretical modeling, Messner et al. conclude that a "broader systemic approach, such as influencing populations to adopt healthier diets, would result in more sustainable environmental and economic outcomes than a single-minded focus on supply restraint to reduce food waste."[63] Luckily, waste reduction is a popular idea with at least part of the Northfield community, [64] so the City may be able to garner public support for ambitious waste reduction policies through appropriate education and public engagement initiatives. Additional research is needed to analyze the effectiveness of specific top-down waste prevention and diversion measures implemented elsewhere - such as charging a deposit on plastic and glass bottles,[65] implementing deposit return systems for such

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[57] Chettiyappan Visvanathan and Prakriti Kashyap, "Public Engagement for Implementation of Waste Reduction and Recycling Policies," in *Sustainable Solid Waste Management*, ed. Jonathan W-C Wong et al. (Reston, Virginia: American Society of Civil Engineers, 2016), 135.

[58] "Garbage," City of Northfield, MN, accessed February 9, 2021, https://www.ci.northfield.mn.us/1302/Garbage.

[59] "Rates," Recology, accessed February 9, 2021, https://www.recology.com/recology-san-francisco/rates/.

[60] Zero Waste Plan; Katia Lasaridi, "Waste Prevention," 88.

[61] "Waste Wise," Minnesota Chamber of Commerce, accessed March 10, 2021, https://www.mnchamber.com/your-opportunity/waste-wise.

[62] Northfield Climate Action Plan, 38; Zero Waste Plan, 17.

[63] Messner, Richards, and Johnson, "The 'Prevention Paradox': food waste prevention and the quandary of systemic surplus production," 813.

[64] In a 2018 survey for the CAP, 91% of respondents reported trying to reduce waste. However, the study used a convenience sample, and the results suggested that respondents were likely more highly educated and motivated to engage with environmental efforts than is probably representative of the overall population. Northfield Climate Action Plan, Appendix D.

[65] David E. Newton, *Waste Management* (Santa Barbara: ABC-CLIO, 2020), 41.

items,[66] banning disposable straws, and restricting the use of single use plastics[67] - and to determine how these policies can gain widespread support and acceptance.

Many of the education and publicity efforts outlined in this section would benefit from an organized volunteer base. The Volunteer Coordinator position could help connect residents and college students with opportunities to support waste prevention efforts, such as going door-to-door to disseminate information or distribute "no junk mail" stickers, running afterschool programs for kids, and compiling information about recyclable items.

3. Encourage Local Participation

Even the best-laid plans cannot succeed without public participation and support. Numerous articles from the literature support the crucial role of community engagement for waste prevention.[68] As John Barry argues, community engagement is essential to changing attitudes and behavior towards waste and motivating lasting environmental action.[69] The following recommendations focus on ways that Northfield can encourage community participation in waste management and foster local organizations that contribute to waste prevention and diversion. Not only will this improve waste management in Northfield, but it will also support social equity and economic development. These objectives are ambitious and will not be quick to achieve. As a result, this stage of the plan aims for a 10-15 year timeframe and will be supported by previous stages: reliable measurement of waste production and prevention will reveal areas where improved management is needed, and awareness campaigns and waste prevention incentives will build demand for reuse and diversion services and encourage support of local organizations focused on waste management.

In the early days of recycling, materials were often collected and sorted at the community level by nonprofit organizations. For example, the Resource Centre and Uptown Recycling Inc. originated in poor minority communities of Chicago and paid community members for recyclable materials recovered from dumpsters or from households. Motivated primarily by social and environmental goals, rather than profit, these organizations provided employment opportunities, produced high-quality recyclable material, and even "recycled" vacant lots into parks.[70] This model of waste diversion was pushed out by the advent of single-stream recycling handled by large waste management corporations. Although the single-stream model has made recycling more convenient and increased the number of people participating, revisiting the idea of community-level recycling may be worthwhile.

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[66] Katia Lasaridi, "Waste Prevention," 70.
[67] Mandatory Recycling and Composting, City of San Franscisco 100-09, (2009).
[68] Visvanathan and Kashyap, "Public Engagement for Implementation of Waste Reduction and Recycling Policies," 137; Bartl, "Moving from recycling to waste prevention: A review of barriers and enables."; Pietzsch, Ribeiro, and de Medeiros, "Benefits, challenges and critical factors of success for Zero Waste: A systematic literature review."
[69] John Barry, "Resistance is Fertile: From Environmental to Sustainability Citizenship," in *Environmental Citizenship*, ed. Andrew Dobson and Derek Bell (Cambridge, MA: MIT Press, 2006); Velenturf and Purnell, "Resource Recovery from Waste: Restoring the Balance between Resource Scarcity and Waste Overload."
[70] David N. Pellow, Allan Schnaiberg, and Adam S. Weinberg, "Advanced industrial countries: Putting the ecological modernisation thesis to the test: The promises and performances of urban recycling," *Environmental Politics* 9, no. 1 (2000), 118.

Some community-level recycling already exists in Northfield. Northfield Curbside Composting provides an excellent example. This small group of worker-owners collects organic waste from 600, or about 10%, of Northfield households.[71] Jim Caswell is another example of community-level recycling; he has collected and recycled electronics from community members for over 40 years. Once a month, he accepts items such as monitors, printers, laptops, battery backups, etc., then disassembles them and sells the parts to recycling centers that extract the valuable metals. This service has been publicized by word of mouth and through the local United Church of Christ community, and now Mr. Caswell receives over a hundred items per month.[72] Efforts like these support the City's waste prevention and sustainability goals.

In addition to the environmental benefits of community-based waste prevention and diversion, expanding this approach will encourage social equity and community wellbeing. For example, Northfield Curbside Composting operates as a worker cooperative where all members of the organization contribute to decision-making and have equal ownership. According to Helen Forsythe, one of the worker-owners, this fosters a democratic and supportive environment, especially important in an industry built on handling others' waste.[73] In addition, the organization leads community outreach efforts, such as events at the local elementary schools to teach kids about composting. This home-grown organization's focus on community and worker wellbeing over profit exemplifies the benefits of a non-profit community-based approach. We must not underestimate the ability of small organizations to make big change.

Recommendations for Encouraging Local Participation

a. Encourage community-level recycling of batteries, plastic film, and other materials that are incompatible with the existing single-stream recycling program
b. Support community-level efforts to prevent waste
c. Support existing community-level recycling efforts such as Northfield Curbside Composting and Jim Caswell's electronics recycling

As outlined above, Northfield already has successful community-based recycling efforts, and there is room for this model to expand in Northfield. Such an approach could be especially useful for items that cannot go in single-stream bins, such as batteries and plastic film. Some commonly used batteries are a source of corrosive materials and heavy metals that contribute to harmful landfill leachate, and increasingly-common lithium-ion batteries even cause fires in landfills.[74] Although landfill technology has improved, a study by the U.S. geologic survey found that all landfills eventually leak,[75] allowing toxic leachate to contaminate the environment.

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[71] "About Us," Northfield Curbside Composting.
[72] Jim Caswell, interview by Irene Stoutland, February 10, 2021.
[73] Forsythe, interview.
[74] Kevin M. Winslow, Steven J. Laux, and Timothy G. Townsend, "A review on the growing concern and potential management strategies of waste lithium-ion batteries," *Resources, Conservation and Recycling* 129 (2018).
[75] "The Norman Landfill Environmental Research Site: What Happens to Waste in the Landfills?," U.S. Geological Survey, updated August, 2003, accessed February 9, 2021, https://pubs.usgs.gov/fs/fs-040-03/#protection1988.

Although recycling batteries is not yet always profitable,[76] diverting batteries from the landfill will ease the burden of landfill management, decrease the environmental impact of landfills, save money in environmental cleanup costs, and decrease the need to extract toxic minerals from the earth.[77]

Although there is a recycling outlet for batteries, collection is a challenge. Minneapolis used to provide drop-off sites for batteries at city and county buildings, libraries, schools, and community centers, but discontinued the practice because of the increased fire risk posed by battery recycling containers contaminated with vape cartridges.[78] Now batteries must be brought to county drop-off locations. There are difficulties in collecting specific recyclables on a city- or county-wide scale, so this could be a productive space for community-level programs. A program could encourage schools or neighborhoods to collect batteries and award a prize to the group that collected the most. Similar strategies have been employed elsewhere.[79] This friendly competition and gentle social pressure can encourage behavior change, as shown in a study by Ferraro & Price stating that social comparison is a powerful factor in decreasing water consumption.[80]

In addition to community-based recycling efforts, local initiatives can also tackle waste prevention through reuse and resource sharing. Gregson et al. identify reuse as a crucial strategy for preventing waste in the UK and find that people are motivated to participate in second-hand trading more for its social value and frugality than in an effort to reduce waste. As a result, the study concludes that making reuse and exchange of goods more convenient and accessible to residents is an effective way to promote reuse and reduce consumption.[81] Bartl likewise argues that reuse has large potential for waste prevention but that producers may not be interested in repair and reuse due to the larger profit generated by producing a new item.[82]

Northfield has successfully promoted reuse in the past and can expand this strategy for waste prevention in the future. For example, Carleton College has hosted a Repair Fair where volunteers fix broken items in order to encourage reuse and waste prevention.[83] Although this event did include both students and Northfield community members, the city could hold a similar

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[76] "Battery Recycling as a Business," Battery University, accessed February 9, 2021, https://batteryuniversity.com/learn/article/battery_recycling_as_a_business.
[77] Winslow, Laux, and Townsend, "A review on the growing concern and potential management strategies of waste lithium-ion batteries."
[78] "Batteries no longer accepted in Minneapolis recycling, some may go in trash," City of Minneapolis, updated November 19, 2019, accessed February 9, 2021, http://news.minneapolismn.gov/2019/11/19/batteries-no-longer-accepted-minneapolis-recycling-may-go-trash; "Battery Recycling," Hennepin County, MN, accessed February 9, 2021, https://www.hennepin.us/batteryrecycling.
[79] "3R Bazaar: Battery Recycling," The Woodlands Township Environmental Services Department, accessed February 9, 2021, https://thewoodlandstownshipblog-environment.com/2019/10/01/3r-bazaar-battery-recycling; "Ontario Schools Battery Recycling Challenge," Ontario Public Schools, accessed February 9, 2021, https://www.rawmaterials.com/ontario-school-recycling-challenge/school/.
[80] Ferraro and Price, "Using Nonpecuniary Strategies to Influence Behavior: Evidence from a Large-Scale Field Experiment."
[81] Gregson et al., "Moving up the waste hierarchy: Car boot sales, reuse exchange and the challenges of consumer culture to waste prevention."
[82] Bartl, "Moving from recycling to waste prevention: A review of barriers and enables."
[83] "'Repair Fair' educates on waste reduction, reuse," Carleton College, updated April 14, 2018, accessed March 4, 2021, https://www.carleton.edu/news/stories/repair-fair-educates-on-waste-reduction-reuse/.

event more intentionally aimed at the broader Northfield community, perhaps in collaboration with the colleges. Other cities have successfully held such events.[84] The Cannon Valley Makers describes itself as a group of "woodworkers, teachers, techies, and entrepreneurs" and operates out of a community workshop in Dundas.[85] This community organization could be a valuable partner in organizing a repair and reuse event. In addition, reviving a forum where residents can share goods and services, such as the Northfield Community Exchange, could help combat the waste problem and encourage social equity. This resource-sharing model allows people to borrow equipment such as power tools, lawnmowers, and other appliances instead of purchasing these items and puts residents in contact with people who may be able to help them repair existing items, thereby reducing consumption of goods and preventing waste. In addition, the City could consider expanding its capacity to accept donations of used goods and sell them to community members. Not only would this demonstrate the City's commitment to reuse and waste prevention, but it would also provide a source of revenue that could be directed towards other waste prevention and diversion initiatives.

The City could encourage this community-based model by offering small grants or aid in securing funding to help local initiatives get off the ground. In addition, the City must incorporate these small businesses if city-wide plans are implemented. For example, a contract with Dick's Sanitation for city-wide composting could drive Northfield Curbside Composting out of business, but the City could work with these businesses to find a way for them to coexist. This will set an important precedent that Northfield supports its community-based waste prevention and diversion efforts. The City could also seek funding to use in support of these initiatives through the Solid Waste Processing Facilities Capital Assistance Program through the Minnesota Pollution Control Agency (MPCA), which provides assistance to local governments in improving their waste management systems. Eligible projects include recycling and composting, among others. The City could also help small organizations apply for MPCA Recycling Market Development grants, which Northfield Curbside Composting recently received. [86]

Many of the recommendations in this section require cooperation between the City and community. The Volunteer Coordinator position previously recommended could facilitate this cooperation by, for example, recruiting volunteers to participate in a repair-fair event or to collect used items for donation. Hiring a dedicated staff person to organize and promote volunteering would be invaluable to waste prevention and diversion efforts, as well as many other initiatives.

4. Support State and National Legislation

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[84] Zach DeLuca, "Northfield Fix-It Fair postponed indefinitely," *Greenfield Recorder* (Greenfield, MA), April 14 2020, https://www.recorder.com/B1-Northfield--fix-it-Fair-33770988.
[85] "Cannon Valley Makers," St Olaf College, accessed March 4, 2021, https://pages.stolaf.edu/cannonvalleymakers/.
[86] "Solid Waste Processing Facilities Capital Assistance Program," Minnesota Pollution Control Agency, accessed March 10, 2021, https://www.pca.state.mn.us/waste/solid-waste-processing-facilities-capital-assistance-program; "Recycling market development grants," Minnesota Pollution Control Agency, accessed March 10, 2021, https://www.pca.state.mn.us/waste/grant-recycling-markets.

Changes in production and consumption habits are necessary for Northfield to achieve its Zero Waste goals. Although the City can take steps to prevent and divert waste, it cannot create a waste-free island in a society driven by high production and consumption of low-durability goods. Improvements in the way products are designed and manufactured can decrease packaging waste, create goods that last longer and are more reusable, and result in products that are easier to recycle. According to Bartl, preventing waste is not in the economic interests of companies.[87] As a result, changes in production will require legislation at the state and national levels, and Northfield can support these changes. This is the last section of my plan, focused on the next 10-20 years, because Northfield cannot directly implement these changes. Despite the importance of societal change, the City must prioritize local initiatives, such as those recommended above, where it can have a more direct and productive impact.

Waste has historically been tied to economic growth. When the economy is booming, demand for products drives increased production and consumption, which supports further growth. Lasaridi et al. propose that consumer demand drives production practices and change must arise from individual choices. Messner et al. point out that the larger production systems influence and limit consumer choice through packaging, promotional offers, portion sizes, and advertising, and thusly bear much of the responsibility for waste production.[88] The latter group conclude that we must decouple waste from economic growth by encouraging growth in the service sector and less "resource-intensive profit models."[89] Messner et al. even argue that society must exercise restraint in creating supply that greatly exceeds demand but acknowledge the potential negative economic impacts of such a change. Despite its environmental benefits, reduced consumption meets strong opposition from powerful economic and investment interests. The waste management industry has invested substantially in infrastructure and technology and has an economic interest in managing, rather than preventing, waste. This often leads industry and government to publicly proclaim a preference for waste prevention but provide material support for diversion over prevention, which may present a barrier to shifting from the former to the latter.[90] Becoming a Zero Waste society will require decreasing overproduction and overconsumption, which will undoubtedly prove a long and difficult fight.[91]

But more careful resource use and economic growth are not incompatible. According to Gentil et al, extending product life span, favoring services over equipment purchasing, and reducing the use of hazardous materials enhances long-term resource security and supports a sustainable economic model.[92] New jobs will be created related to waste prevention, and businesses can save money by decreasing wasteful use of resources. Waste prevention can even

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[87] Bartl, "Moving from recycling to waste prevention: A review of barriers and enables."
[88] Katia Lasaridi, "Waste Prevention," 78; Messner, Richards, and Johnson, "The 'Prevention Paradox:' food waste prevention and the quandary of systemic surplus production."
[89] Gentil, Gallo, and Christensen, "Environmental evaluation of municipal waste prevention."
[90] Messner, Richards, and Johnson, "The 'Prevention Paradox:' food waste prevention and the quandary of systemic surplus production."
[91] Gentil, Gallo, and Christensen, "Environmental evaluation of municipal waste prevention," 2378; Messner, Richards, and Johnson, "The 'Prevention Paradox:' food waste prevention and the quandary of systemic surplus production."
[92] Katia Lasaridi, "Waste Prevention," 62.

benefit the waste management industry by extending the lifetime of landfills, decreasing the presence of hazardous materials that produce toxic leachate, and decreasing the need for management of landfill gas. In addition, Lasaridi et al. predict that waste production is unlikely to decrease by more than 10-15% in the foreseeable future,[93] so the waste management industry will be essential for years to come.

Recommendations for Supporting State and National Legislation

a. Support extended producer responsibility legislation on the state and national levels

Although Northfield has little control over broad economic and production trends, the city can and must pressure businesses and the state government to enact changes that will support Northfield's Zero Waste goals. Some countries, such as South Korea, Germany, and Belgium, have achieved high recycling rates through extended producer responsibility, whereby the cost of recycling or disposing of an item, such as carpet, electronics, and batteries, is added to the cost up front or producers are required to buy back waste from their products.[94] According to Abbasi, this encourages the production of less wasteful products and easier-to-recycle packaging; supports the use of more sustainable alternative materials, such as plastics made from natural materials;[95] discourages production of items that are very difficult to recycle, like coated paper, plastic with additives, and other combined materials; and provides revenue to pay for recycling programs.[96] In contrast, Bartl argues that extended producer responsibility does not lead to changes in production because producers would rather pay a fee than reduce waste generation.[97] Even if this is the case, these fees can fund recycling and waste prevention initiatives.

Northfield's ZWP supports efforts to hold producers accountable and recommends point-of-purchase fees for hazardous materials such as motor oil and herbicides. The extended producer responsibility approach is gaining support at the state level as well in Minnesota; Rep. Rick Hansen, who chairs the Environment and Natural Resources Finance and Policy Committee in the Minnesota House, favors bringing producer responsibility laws up for debate in the Legislature.[98] State support can and must help cities prioritize waste prevention initiatives and support their capacity to make change.[99]

Conclusion

[93] Katia Lasaridi, "Waste Prevention," 78.
[94] E-waste is especially difficult to manage; it is often sent to developing countries and dismantled in informal and labor-intensive processes, which can expose workers and the environment to toxic heavy metals. Abbasi, "The myth and the reality of energy recovery from municipal solid waste."
[95] Julia L. Shamshina, Paula Berton, and Robin D. Rogers, "Advances in Functional Chitin Materials: A Review," *ACS Sustainable Chemistry & Engineering* 7, no. 7 (April 1, 2019).
[96] Abbasi, "The myth and the reality of energy recovery from municipal solid waste."
[97] Bartl, "Moving from recycling to waste prevention: A review of barriers and enables."
[98] Roper, "Twin Cities faces 'pinch point' over landfilling."
[99] Debbie Goettel, Fran Miron, and Victoria Reinhardt, "We have, and need, better alternatives than landfills," *Star Tribune* (Minneapolis, MN), February 14 2021, https://www.startribune.com/we-have-and-need-better-alternatives-than-landfills/600023217/.

There are no easy solutions to the waste management problem. Waste production will continue to increase unless the problem is aggressively addressed, and my 20-year plan outlines concrete steps that Northfield can take now to support its long-term goal of eliminating waste sent to landfill. This plan sets out reasonable goals and proposes specific objectives to better reduce and manage waste. Northfield should first establish reliable measurement of waste, then prioritize initiatives to prevent waste and encourage community participation. The early sections of the plan – measurement and prevention initiatives – will build support and demand for local services that enable increased reuse, recycling, and composting. Each of these stages will encourage support for state and national legislation that will support Northfield's Zero Waste goals. Because the recommendations presented here require coordination between the City and community members, hiring a Volunteer Coordinator would be of great value to Northfield's waste reduction goals. Although Northfield is not experiencing a visibly acute waste crisis, it is in the City's best interest to address waste before the Rice County Landfill fills up and final disposal becomes more difficult. Preventing and diverting waste will reduce Northfield's greenhouse gas emissions and environmental footprint and will help the City build a sustainable long-term future.

Additional Research

Additional research is needed to fully understand the waste management issue in Northfield. For example, the ZWP recommends eliminating waste at City events. What will this require? What are the barriers to implementing this policy? How can the City reduce waste in day-to-day operations?

More research is needed to see if it would be advantageous and feasible for Northfield to run a waste management system independently or in collaboration with neighboring townships. Direct management of waste would allow the City to address greenhouse gas emissions from waste and consider waste-to-energy technology.

Enforcing correct composting and recycling is also an important element in a waste management system, because contaminated refuse may be sent to the landfill. In San Francisco, if a waste collector finds materials in the wrong container, they must leave a tag identifying the incorrect materials, and if the behavior continues, the collector may refuse to empty the container and instead leave a tag and written notice describing what action must be taken for materials to be collected.[100] Would it be feasible or effective for Northfield to enforce correct waste sorting practices?

Construction and demolition waste would also be a productive area for future research. Would using trash to produce construction materials be a productive practice in Northfield?[101] In what other ways could construction waste be minimized?

Equity and accessibility are also important elements to consider in relation to waste management. For example, is recycling available to residents living in trailer parks and

[100] *Mandatory Recycling and Composting*.
[101] Massoud Sofi et al., "Transforming Municipal Solid Waste into Construction Materials," *Sustainability* 9, no. 11 (2019).

apartment buildings? Is the additional cost of compost service a barrier to residents? How could the City make waste diversion activities accessible and convenient for all residents? Additional investigations will paint a more complete picture of waste management in Northfield and inform recommendations going forward.

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Appendix 1: Greenhouse Gas Emissions, Landfill Gas Capture, and Waste-to-Energy Technology

Research supports the necessity of improved waste management in addition to waste prevention efforts. A study by Gentil et al. compared the environmental impact of waste reduction in high-level vs low-level waste management systems. High-level systems are technologically advanced waste management systems and include technologies such incineration and recycling. In low-level waste management systems, most waste is landfilled. A low-level system with modest waste prevention was found to have a more negative environmental impact than a high-tech system without any waste prevention.[102] This suggests that appropriate technology for dealing with waste is essential, especially in the short term, as our society (hopefully) transitions away from its current patterns of indiscriminate consumption and waste.

Even if waste prevention and diversion efforts are successful, the organic waste that has already been landfilled is producing methane, a greenhouse gas much more potent than carbon dioxide. When waste is first deposited in the landfill, organic material decomposes aerobically for less than a year until the waste is buried and deprived of oxygen, establishing the anaerobic conditions that cause microorganisms to produce methane. Municipal solid waste landfills are the third largest methane source from humans, accounting for 15.1% of emissions in 2018 - that's the equivalent of 20.6 million passenger vehicles driven for one year.[103] The Rice County landfill produced the equivalent of 50,379 metric tons of CO_2 in 2019: that's the equivalent of 10,950 cars driven for a year.[104] Although strategies to aerate waste and encourage aerobic decomposition, which produces carbon dioxide, in place of anaerobic decomposition, which produces methane, have been attempted elsewhere, these strategies add greatly to the cost of landfill maintenance.[105]

Landfill gas can be captured by pipes buried in the trash that convey it to the surface, where it is released, burned unproductively (flared), or collected and used for energy generation.[106] Capture for energy production is the most sustainable management technique for landfill gas. Once captured, the gas can be upgraded to pipeline-grade natural gas, used directly for combustion applications (such as heating), or used to generate electricity with small turbines onsite.[107] Cogeneration is especially efficient because it produces power and captures the waste heat as steam or hot water.

The Rice County Solid Waste Facility has investigated landfill gas capture in the past and concluded that the technology to transport the gas to somewhere it could be utilized was too

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102 Gentil, Gallo, and Christensen, "Environmental evaluation of municipal waste prevention."

103 "Frequently Asked Questions About Landfill Gas," United States Environmental Protection Agency, accessed February 9, 2021, https://www.epa.gov/lmop/frequent-questions-about-landfill-gas#howdatarelated.

104 "GHGRP Waste," United States Environmental Protection Agency, accessed February 9, 2021, https://www.epa.gov/ghgreporting/ghgrp-waste.; the CAP estimated that Northfield specifically produced 27,545 tons of waste in 2017, generating 3,737 metric tons of GHGs, but does not specify what type of GHG. The majority of those emissions came from landfilled waste, especially organic matter (e.g., food, yard scraps). Northfield Climate Action Plan.

105 Abbasi, "The myth and the reality of energy recovery from municipal solid waste."

106 Lyle, "Waste as a Resource."

107 "Basic Information About Landfill Gas," United Stated Environmental Protection Agency, accessed February 10, 2021, https://www.epa.gov/lmop/basic-information-about-landfill-gas.

expensive to implement for the amount of landfill gas produced.[108] Northfield aims to eliminate greenhouse emissions from waste by 2030, and strategies to control landfill gas may be necessary to achieve this goal.[109] The Rice County Landfill could avoid the costs of transporting or upgrading its landfill gas by using it onsite to heat and power the facility or to evaporate waste paint or landfill leachate. Additional research is needed to determine the specific cost and payoff of installing a system for onsite utilization of landfill gas. Flaring is a cheaper option because it requires very little investment in equipment. Although it does not produce energy, it at least reduces the warming potential of the gas by converting it from methane to carbon dioxide.

There are limitations to landfill gas capture and utilization; only 60-90% of landfill gas can be captured, and landfills typically only produce gas at a level high enough for recovery at reasonable cost for 7-10 years, although gas continues to be produced for several decades.[110]

Waste-to-energy strategies, such as incineration and anaerobic digestion, can also be used to manage waste but are not recommended for use in Northfield. Incineration, common in the Twin Cities, reduces waste volume but produces polluting emissions such as carbon monoxide, sulfur and nitrogen oxides, dioxins, heavy metals, and other pollutants.[111] The process makes toxic metals more likely to escape into the environment and produces ash much more hazardous than the original waste. Managing the emissions from incineration is possible, but very expensive, and the energy produced is often more expensive than that from the grid.[112] Anaerobic digestion uses organic waste to produce methane in a closed system, allowing all biogas to be collected. Fernández-González et al. conducted a review of waste management technologies and recommended this strategy for use by small municipalities in southern Spain.[113] Although this is an efficient strategy for fluid wastes such as distillery and food industry wastewaters, solid waste requires extensive pre-treatment and is unlikely to produce net energy.[114] Gasification may provide a cleaner and more efficient waste-to-energy method and is mentioned in the CAP.[115] More research is needed to evaluate the potential for this technology in Northfield. Ultimately, most waste-to-energy strategies require substantial technological investment with low economic and environmental returns.[116] In addition, investment in complex waste-to-energy strategies draws resources away from waste prevention and diversion programs. Viewing waste as a resource can backfire by leading to increased waste production and decreased interest in the most desirable solution: waste prevention.

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[108] Miller, interview.
[109] Northfield Climate Action Plan, 26.
[110] Abbasi, "The myth and the reality of energy recovery from municipal solid waste."
[111] Lyle, "Waste as a Resource."
[112] Abbasi, "The myth and the reality of energy recovery from municipal solid waste."
[113] J. M. Fernández-González et al., "Economic and environmental review of Waste-to-Energy systems for municipal solid waste management in medium and small municipalities," *Waste Management* 67 (2017).
[114] Abbasi, "The myth and the reality of energy recovery from municipal solid waste," 8.
[115] Northfield Climate Action Plan, 30.
[116] "Energy Recovery from the Combustion of Municipal Solid Waste (MSW)," United States Environmental Protection Agency, accessed February 10, 2021, https://www.epa.gov/smm/energy-recovery-combustion-municipal-solid-waste-msw.